POLISH JOURNAL OF FOOD AND NUTRITION SCIENCES

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Pol. J. Food Nutr. Sci.
2007, Vol. 57, No. 4(C), pp. 551-554

EGGSHELL QUALITY IN LAYING HENS FED DIETS SUPPLEMENTED WITH DIFFERENT LEVELS OF ZINC AND MANGANESE

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Key words: eggshell quality, zinc, manganese, laying hens

The aim of the study was to evaluate the effect of zinc and manganese levels in the diet for laying hens on eggshell percent, thickness, density and eggshell breaking strength. Experiment was carried out on 90 Hy Line Brown hens, from 25 to 70 weeks of age, allocated to 10 experimental groups, each containing 9 hens individually caged on wire-mesh floor. All layers were fed the same basal diet, containing recommended amounts of all nutrients, except zinc and manganese, because vitamin-mineral diet without these microelements was used. In the experimental groups basal diet was supplemented with increasing levels of Zn and Mn (as ZnO and MnO forms), in the amounts from 0 to 100 mg/kg.

The used levels of addition of the studied microelements had no effect on laying performance. Supplementation of basal diet with Zn and Mn did not influence eggshell percent, thickness and density. Addition of Mn to the basal diets increased the eggshell breaking strength in second phase of laying cycle. Enriching the basal diet with Zn had no effect on this parameter. In all experimental groups there was highly significant, negative correlation between hen age and eggshell breaking strength. Based on linear regression equations it was found that diet supplementation with 20 mg Mn/kg reduced negative effect of layer age on shell breaking strength by 43%, while the simultaneous addition of 20 mg Zn/kg and 50 mg Mn/kg – by 46%.

INTRODUCTION

Eggshell quality is one of the most important problems in poultry industry, influencing economic profitability of eggs production and eggs hatchability. High eggshell breaking strength and lack of shells defects are essential for protection against penetrating of pathogenic bacteria such as *Salmonella sp*. into the eggs. It has been estimated that eggs with damaged shells account for 8-10% of all produced eggs, what leads to great economic losses (Roland 1988). The poor shell quality is especially observed during second phase of laying period. Most of studies on nutrition effects on eggshell quality have been focused on macrominerals (Ca, P) and vitamin D_3.

Although it is known, that enzymes related with some microelements are essential in eggshell formation, the number of studies on relationship between trace elements and shell quality is limited. Zinc and manganese, as components of metaloenzymes responsible for carbonate and mucopolysaccharides synthesis, play an important role in eggshell formation. In previous study of Stahl *et al.* [1986] the level of 30 mg Zn/kg diet was sufficient for high eggshell quality, but Zamani *et al.* [2005] stated, that supplementation of basal diet contained 50 mg Zn/kg with additional amounts of Zn had positive effect on eggshell thickness. Positive effect of manganese addition to the diet on some eggshell parameters was observed by Abdallah *et al.* [1994] and Hossain *et al.* [1994]. Inal *et al.* [2001] noted, that 25 mg Mn/kg in the diet is sufficient for maximum egg production, egg weight and feed conversion, but for optimal shell quality the requirement of layers is much higher.

The aim of the present experiment was to study the effect of zinc and manganese level of addition to the maize-wheat-soybean diet for laying hens on eggshell quality, measured as percent, thickness, density and breaking strength of eggshells.

MATERIALS AND METHODS

Experiment was carried out on 90 Hy Line Brown laying hens from 25 to 70 weeks of age. At the beginning of experiment hens were divided to 10 experimental groups, each containing 9 birds, individually caged on wire-mesh floor. Cages were 40 cm wide and 40 cm deep. During the experiment hens were offered water and feed *ad libitum* and were exposed to a 14 L: 10 D lighting schedule, with dark period at night.

All hens were fed the same basal mash diet contained 25.5% wheat, 34% maize and 19.2% extracted soybean meal. The basal diet was formulated to meet requirements of hens, with the exception of Zn and Mn, because vitamin-mineral premix without these microelements was used. The basal diet was supplemented with increasing levels of zinc and manganese (as ZnO and MnO forms), in the amounts from 0 to 100 mg/kg (Table 1).

During experiment one egg from each hen at 35, 48, 62 and 70 weeks of age was collected to determine the shell quality parameters (shell thickness, shell density, shell percent in

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TABLE 1. Experimental design.

Number of group	Level of Zn addition to the basal diet (mg/kg)	Level of Mn addition to the basal diet (mg/kg)
I	–	–
II	20	-
III	-	20
IV	20	20
V	50	20
VI	20	50
VII	50	50
VIII	100	50
IX	50	100
X	100	100

egg) using EQM, version 3.1 of egg quality assessment instrument operating. At 35, 48, 53, 58, 62, 66 and 70 weeks of age two eggs from each bird were collected for measurements of shell breaking strength (using Instron 5542 with constant speed of head – 10 mm/min). Average value for two eggs laid by the same hen was subjected to the statistical calculations.

The data were subjected to statistical analysis using one-way factorial analysis of variance. The significance of differences between means was determined by Duncan's multiple range test. For determination of correlation between hens age and eggshell breaking strength in each group the Pearson's correlation coefficient and linear regression equations were calculated (using model: Y = a + bx).

RESULTS AND DISCUSSION

The average laying rate for whole laying period was 90.0%; mass of 1 egg – 61.4 g; feed conversion per 1 egg – 128 g and per 1 kg of eggs – 2.13 kg. Supplementation of basal diet with studied microelements had no effect on performance parameters ($p>0.05$). Similar results were obtained by Guo *et al.* [2002], who stated no effect of supplementation of basal diet (30 mg Zn/kg) with 40, 80, 120 or 140 mg Zn/kg on laying performance. Hossain *et al.* [1994] noted, that addition of 20, 40 or 80 mg Mn/kg to basal diet (25 mg Mn/kg) did not affect production parameters of layers. However in the later work they observed tendency to increase egg production and egg weight after supplementation the basal diet with 50 or 75 mg Mn/kg [Hossain & Bertechini, 1998].

The average shell percent in egg mass for all experimental groups was – 9.45%; shell thickness – 371 μm and shell density – 80.0 mg/cm^2 (Table 2) and there were no differences between experimental groups ($p>0.05$). Differently from presented results Hossain *et al.* [1993] stated, that supplementation of basal diet with Mn had positive effect on shell thickness. In the study of Fassani *et al.* [2000], Mn addition (40-200 mg/kg) to the diet for leghorn hens in the second cycle of production, improved shell thickness and egg loss indexes. The highest shell thickness was observed when the diet was supplemented with 200 mg Mn/kg. In the previous study [Holder & Huntley, 1978] supplementation of basal diet with 65 mg Mn/kg increased eggshell thickness, but addition of 130 mg Zn/kg had no effect on this parameter.

TABLE 2. Eggshell parameters in different phases of experiment.

Number of group	Weeks of hens age				Overall mean
	35	48	62	70	
Eggshell percent (%)					
I	9.53	9.35	9.22	9.40	9.38
II	9.41	9.59	9.27	9.43	9.42
III	9.62	9.73	9.70	9.23	9.57
IV	9.42	9.61	9.46	9.24	9.43
V	9.48	9.64	9.33	9.45	9.47
VI	9.42	9.55	9.32	9.56	9.46
VII	9.51	9.66	9.29	9.32	9.44
VIII	9.40	9.54	9.60	9.50	9.51
IX	9.40	9.62	9.48	9.37	9.47
X	9.36	9.30	9.32	9.39	9.34
SEM	0.0363	0.0468	0.0507	0.0509	0.0282
P level	NS	NS	NS	NS	NS
Eggshell thickness (μm)					
I	368	376	371	368	371
II	363	375	365	371	368
III	377	379	379	360	374
IV	368	370	377	368	371
V	375	378	379	374	376
VI	373	375	367	375	373
VII	375	379	362	370	371
VIII	374	368	382	362	371
IX	367	379	377	365	372
X	362	366	364	371	366
SEM	1.58	1.91	2.10	2.34	1.13
P level	NS	NS	NS	NS	NS
Eggshell density (mg/cm^2)					
I	80.9	80.3	78.2	77.7	79.3
II	79.4	81.9	78.7	79.7	79.9
III	80.8	82.1	81.2	79.0	80.8
IV	78.7	81.4	80.8	78.3	79.8
V	80.4	82.0	79.2	80.5	80.5
VI	79.9	81.2	80.6	80.6	80.6
VII	80.6	81.9	79.5	79.5	80.4
VIII	79.5	78.9	80.9	79.7	79.8
IX	78.2	81.7	81.1	79.1	80.0
X	77.8	78.2	78.5	79.4	78.5
SEM	0.322	0.416	0.440	0.503	0.270
P level	NS	NS	NS	NS	NS

NS – $p>0.05$

Addition of Mn to the basal diet positively affected eggshell breaking strength at 48, 53, 58, 62, 66 and 70 weeks of age ($p\leq0.05$), but addition of Zn had no influence on this parameter in any of measurement date (Table 3). Beneficial

TABLE 3. Eggshell breaking strength (N) in different phases of experiment.

Number of group	Weeks of hen age							Overall mean
	35	48	53	58	62	66	70	
I	39.1	32.0a	31.1a	31.4a	31.2a	30.0a	29.7a	32.1a
II	38.4	33.4ab	30.6a	31.5a	31.0a	32.5ab	30.7ab	32.6a
III	39.8	36.3b	36.4b	36.2b	35.9bc	35.6bc	34.2c	36.3b
IV	40.0	36.5b	35.4b	35.8b	34.1b	35.8c	32.5bc	35.7b
V	41.9	36.5b	35.6b	36.1b	35.1bc	35.0bc	34.1c	36.3b
VI	41.8	35.8b	37.1b	37.8b	37.6c	35.8c	34.2c	37.1b
VII	42.3	36.4b	36.1b	36.3b	37.1bc	36.1c	34.1c	36.9b
VIII	40.6	36.6b	36.5b	35.4b	35.8bc	34.5bc	33.1bc	36.1b
IX	40.8	36.9b	36.0b	36.9b	36.7bc	34.6bc	33.9c	36.5b
X	41.5	36.3b	36.2b	35.7b	37.0bc	34.5bc	33.9c	36.4b
SEM	0.538	0.371	0.491	0.349	0.383	0.345	0.461	0.248
P level	NS	*	**	***	***	**	*	***

a, b, c – values in columns marked with different superscripts are significantly different at $p \leq 0.05$; S – $p > 0.05$, * – $p \leq 0.05$, ** – $p \leq 0.01$, *** – $p \leq 0.001$

TABLE 4. Correlation between eggshell breaking strength and hens age calculated using linear regression equations.

Number of group	Linear regression equation Y = a + bx	Linear regression coefficient (b) (%)	Correlation coefficient (r)
I	Y = 47.3 – 0.2699x	100	- 0.768***
II	Y = 46.2 – 0.2497x	92.5	- 0.705***
III	Y = 45.0 – 0.1539x	57.0	- 0.557***
IV	Y = 45.8 – 0.1800x	66.7	- 0.549***
V	Y = 46.5 – 0.1819x	67.4	- 0.564***
VI	Y = 45.2 – 0.1453x	53.8	- 0.463***
VII	Y = 45.6 – 0.1576x	58.4	- 0.501***
VIII	Y = 45.9 – 0.1758x	65.1	- 0.585***
IX	Y = 45.5 – 0.1616x	59.9	- 0.548***
X	Y = 46.0 – 0.1718x	63.7	- 0.501***

***$p \leq 0.001$; Y – eggshell breaking strength (N); x – weeks of hens age

effect of diet supplementation with Mn on eggshell breaking strength observed also Ochrimenko *et al.* [1992]. Mabe *et al.* [2003] stated, that addition of 60 mg Zn/kg, 60 mg Mn/kg and 10 mg Cu/kg to the basal diet increased eggshell resistance in hens from 60 to 82 weeks of age, but in younger hens they did not observe any effect.

The tendency for decrease of eggshell breaking strength with hens age was observed in the experiment. Average breaking strength at 35 weeks was 40.2 N and diminished to 32.8 N at 70 weeks of age. Similar tendency was noted among others by Al-Batsan *et al.* [1994] and De Ketelaere *et al.* [2002]. Based on linear regression equations (Table 4) it could be stated, that diet supplementation with 20 mg Mn/kg reduced the negative effect of hens age on eggshell breaking strength by 43%, while the simultaneous addition of 20 mg Zn/kg and 50 mg Mn/kg – by 46%.

CONCLUSIONS

In conclusions, it could be stated, that the feed compounds used in basal diet contained sufficient amounts of zinc and manganese for optimal laying performance and eggshell percent, thickness and density. In second phase of laying cycle, the use of basal not supplemented diet negatively affected eggshell breaking strength. Enrichment of basal diet with 20 mg Mn/kg or simultaneously with 20 mg Zn/kg and 50 mg Mn/kg positively corrected negative effect of hens age on eggshell breaking strength.

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WPŁYW ZAWARTOŚCI CYNKU I MANGANU W MIESZANCE PASZOWEJ DLA KUR NIEŚNYCH NA JAKOŚĆ SKORUP JAJ

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Celem badań było określenie wpływu zawartości cynku i manganu w mieszance paszowej dla kur nieśnych na masę, grubość, gęstość i wytrzymałość mechaniczną skorup jaj. Doświadczenia przeprowadzono na 90 kurach nieśnych Hy Line brązowy, w okresie od 25 do 70 tygodnia życia. Utworzono 10 grup doświadczalnych, z których każda składała się z 9 ptaków utrzymywanych w indywidualnych klatkach, przy stałym dostępie do paszy i wody. Stosowano podstawową mieszankę paszową, w skład której wchodziły głównie śruty zbożowe (pszenna i kukurydziana) oraz śruty poekstrakcyjne (sojowa i rzepakowa). Mieszanka podstawowa zawierała normatywną ilość składników pokarmowych. Jedynie poziom cynku i manganu był obniżony, ponieważ stosowano premiks witaminowa-mineralnego nie zawierający tych mikroelementów. W poszczególnych grupach doświadczalnych do mieszanki podstawowej wprowadzano zróżnicowane, w zakresie od 0 do 100 mg/kg, ilości tych mikroelementów (w formie tlenków paszowych).

Poziom dodatku badanych mikroelementów nie oddziaływał na wyniki produkcyjne niosek. Zastosowane poziomy dodatków Zn i Mn nie miały także istotnego wpływu na procentowy udział w masie jaja oraz grubość i gęstość skorupy. W drugiej fazie cyklu nieśnego dodatek Mn do mieszanki podstawowej zwiększał wytrzymałość mechaniczną skorup jaj. Wzbogacenie mieszanki podstawowej w Zn nie wpływało natomiast na wartość tego parametru. We wszystkich grupach doświadczalnych odnotowano wysoko istotną, ujemną korelację pomiędzy wiekiem kur a wytrzymałością mechaniczną skorup. Na podstawie równań regresji liniowej stwierdzono, że wprowadzenie do paszy 20 mg Mn/kg pozwoliło na zmniejszenie negatywnego wpływu rosnącego wieku ptaków na ten parametr o 43%, natomiast równoczesny dodatek 20 mg Zn/kg i 50 mg Mn/kg – o 46%.